

In-use Emission Measurements of Snowmobiles and Snowcoaches in Yellowstone National Park

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EXECUTIVE SUMMARY

The University of Denver conducted a twelve day, winter, emissions measurement program in Yellowstone National Park that involved the collection of emissions data from in-use snowcoaches and snowmobiles between February 7 and February 18, 2005. In all more than 34 hours and 500 miles of mass emissions data were collected from nine snowcoaches and more than 960 snowmobile measurements were made. This report and all of the data sets collected are available for download from www.feat.biochem.du.edu.

- Both snowcoaches and 4-stroke snowmobiles have lower emissions per person than the 2-stroke snowmobiles. 4-stroke snowmobile emissions reductions averaged 61% for CO and greater than 96% for hydrocarbons compared to 2-strokes.
- 4-stroke snowmobiles have lower emissions per person than the measured mix of snowcoaches for CO. However, newer coaches with modern pollution controls have lower per person emissions than the current 4-stroke snowmobiles.
- The reduction in 4-stroke snowmobile hydrocarbons was significant (<96%) and readily observed. Visible exhaust plumes and odor were greatly reduced. The greater engine efficiency is reflected in an improved gas mileage by the 4-stroke snowmobiles.
- Among 4-stroke snowmobiles, the average CO emissions varied by a factor of 3 between manufacturers. The ratio of CO/NO emissions varied greatly based on the engine tuning by the manufacturer.
- The Arctic Cat and Polaris 4-stroke snowmobiles emitted roughly half as much CO and HC as the Ski Doo snowmobiles. No statistically significant difference in emissions was observed by model year.
- Higher CO and HC emissions were observed from the guide snowmobiles that had been turned off and restarted at the entrance gate.
- Snowmobile emissions were NOT observed to increase with speed on a gm/mile basis. Emissions are greatest during initial startup and idling, especially when the engine is cold.
- The mean snowmobile emissions measured in the gate area appear to provide a representative average emissions value for overall park snowmobile operations.
- The conversion vans operate often in off-cycle engine mode when much greater pollutants are emitted. The time weighted off-cycle operations for all the coaches averaged 20% of the time for the inbound trips and 29% for outbound. This is primarily caused by the high load on the engine and underpowered coaches that

causes the transmission to shift up and down. Newer vans with larger engines were found to have lower emissions.

- The Bombardier snowcoach with an uncontrolled carbureted engine had the highest CO and HC emissions and operated in this high region 98% of the time. Extremely high CO emissions were also observed at the west entrance from several additional vintage Bombardiers. Vans and coaches with efficient fuel-injected engines and catalytic converters can be nearly as clean as modern wheeled passenger vehicles.

Summary comparison of snow vehicle emissions (grams/mile/person).

Pollutant	Snowmobiles				Snowcoaches		
	Mean 1999 2-Stroke	Mean 4-Stroke	Lowest 4-Stroke	Highest 4-Stroke	Mean	Lowest Delacy	Highest B709
CO	71	28	25	60	35	0.6	74
HC	92	3.4	3.1	4.7	1.2	0.1	5.9
NO _x	---	3.4	3.3	0.3	2.8	0.2	0.9

Observations

- ☐ The snowcoach fleet needs to be modernized to reduce unnecessary CO and HC emissions. The Bombardiers should be replaced completely with either new emission controlled engines or with more efficient conversion vans.
- ☐ Current conversion vans are often operated outside the performance regions expected by the on-board engine control computer and in the process emitting more pollutants than necessary. The newer vans with the largest possible engines should be encouraged.
- ☐ Newer 4-stroke engine snowmobiles are lower polluting than the previous 2-stroke snowmobiles. Although the hydrocarbons have been reduced a lot, the amount of CO emissions still far exceeds what a late-model sedan or light duty truck emits. Even cleaner snowmobiles could be a target for the future.
- ☐ To further lower emissions and employee exposures at the entrance stations reduce the wait times as much as possible.